PROC. ENTOMOL. SOC. WASH.
81(1), 1979, pp. 75–81

BREEDING TESTS SUPPORT SYNONYMY OF *APANTELES MELANOSCELUS* AND *APANTELES SOLITARIUS* (HYMENOPTERA: BRACONIDAE)

Marjorie A. Hoy and Paul M. Marsh

(MAH) USDA Forest Service, Northeastern Forest Experiment Station, 151 Sanford Street, Hamden, Connecticut 06514 (present address: Department of Entomological Sciences, University of California, Berkeley, California 94720); and (PMM) Systematic Entomology Laboratory, IIBIII, Agric. Res., Sci, and Educ. Admin., USDA, % U.S. National Museum, Washington, D.C. 20560.

Abstract.—The satin moth (*Stilpnotia salicis* (L.)) and the gypsy moth (*Lymantria dispar* (L.)) were accidentally introduced into North America. Classical biological control projects led to the introduction of two closely related braconid parasites, *Apanteles solitarius* (Ratzeburg) and *A. melanoscelus* (Ratzeburg), which were recently synonymized. Hybridization tests were conducted to confirm this synonymy with an *A. solitarius* colony collected from the satin moth in British Columbia in 1975 and an *A. melanoscelus* colony collected from the gypsy moth in Connecticut. Mating occured readily under laboratory conditions, and fertile hybrid female progeny were produced in the F_1 and the backcross generations.

The satin moth (*Stilpnotia salicis* (L.)) and the gypsy moth (*Lymantria dispar* (L.)) are exotic pests and have been the targets of classical biological control programs in North America, but with differing results (Burgess and Crossman, 1927; Howard and Fiske, 1911; Crossman, 1922; Jones et al., 1938; Brown, 1931; Reeks and Smith, 1956; and Dowden, 1962). The effort against the satin moth has been considered successful (McGugan and Coppel, 1962); the current impact of the satin moth in the northeastern United States is insignificant, whereas the gypsy moth remains a significant problem. One approach that might yield improved control of the gypsy moth is genetic improvement of a parasite through hybridization of different geographical strains (Hoy, 1975a and 1975b).

Apanteles melanoscelus (Ratzeburg) was introduced into New England from Europe in 1911. It is primarily a parasite of gypsy moth larvae but occasionally attacks other moths including the satin moth. In 1927, a species of *Apanteles* determined as *solitarius* (Ratzeburg) was also introduced into New England from Europe. This species is primarily a parasite of the satin

moth but is apparently able to develop on the gypsy moth in the laboratory. From the earliest days of the gypsy moth and satin moth programs there has been confusion about the identities of these two *Apanteles* species (Parker, 1935). Specialists in braconid taxonomy have always had difficulty in distinguishing *melanoscelus* from *solitarius*, and in 1974 the two species were synonymized on the basis of morphological characters (Nixon, 1974). Breeding tests either have not been done or, when done (Parker, 1935), did not provide the sex ratios of the progeny which are necessary in arrhenotokous species.

Therefore we hybridized in the laboratory two colonies obtained from geographically distant sources to determine if these colonies were reproductively isolated or whether *solitarius* could provide an additional gene pool for incorporation into a breeding program of *melanoscelus* (Hoy, 1975a and 1975b).

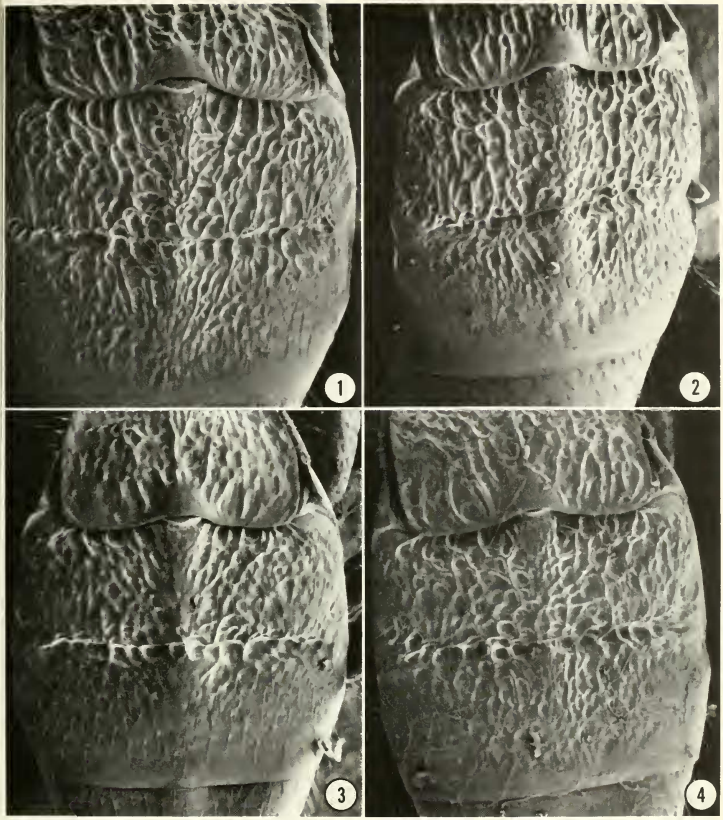
Materials and Methods

Colony Sources and Culture Methods.—The breeding tests were conducted with an *A. melanoscelus* colony from Connecticut (CT) collected from and maintained on the gypsy moth. The *A. solitarius* colony (SOL) from the satin moth was received from British Columbia as cocoons in June 1975. After adults emerged, they were allowed to mate and were given gypsy moth hosts, which they readily parasitized. The colony was subsequently maintained on gypsy moth hosts. This colony (SOL) was classified *solitarius* on the basis of its original host and its geographic source. A few overwintering *A. solitarius* cocoons collected by D. E. Leonard from satin moth hosts in Maine provided three females that were also crossed with CT colony males.

Rearing of *A. solitarius* and *A. melanoscelus* was conducted as previously described (Hoy, 1975a), except that 20 to 25 host larvae were reared in 16 oz. untreated paper food cartons with clear plastic lids, rather than in petri dishes.

Breeding Experiments.—Crosses were made with virgin females isolated as cocoons in No. 000 Lilly[1] gelatin capsules. Newly emerged females were placed into 16 oz. containers with honey, water, and males for mating. After two days, females were given hosts at least twice during their lifetime. At least 10 reciprocal crosses were made between the CT and SOL colonies. Data obtained for individual females included the number of progeny and the F_1 sex ratio. Virgin F_1 females were obtained and were used for reciprocal backcrosses. Again, sex ratio and number of progeny were obtained for each female.

[1] The use of trade, firm, or corporation names is for the information and convenience of the reader and does not imply endorsement or approval by the Forest Service or the Department of Agriculture.



Figs. 1–4. Dorsal view of abdominal terga 2 and 3. 1, Specimen determined as *Apanteles solitarius* from gypsy moth in Massachusetts, 1927, yellow hind femur. 2, Specimen determined as *A. solitarius* from satin moth in Massachusetts, 1930, yellow hind femur. 3, Specimen determined as *A. melanoscelus* from gypsy moth in Massachusetts, 1930, black hind femur. 4, Specimen determined as *A. solitarius* from satin moth in Hungary, 1926, yellow hind femur.

Morphological Examinations.—After crosses had been made and progeny obtained, adult CT and SOL parasites and their F_1 and backcross progeny were preserved in 70% alcohol and studied for morphological variability. Traits particularly examined included the color of the hind femur and the degree of sculpturing on the second and third abdominal terga. About 500

Table 1. Hybridization of *Apanteles melanoscelus* and *A. solitarius*.

Cross No.	Cross ♂ × ♀	Number of crosses	Number of crosses yielding females	% females from total progeny
1	CT × CT	11	9	79
2	SOL × SOL	10	9	54
3	CT × SOL	36	14	59.8
4	SOL × CT	29	12	40.4
5	CT × SOL/CT	11	5	75
6	SOL × SOL/CT	17	6	61.6
7	CT × CT/SOL	15	9	55.7
8	SOL × CT/SOL	21	21	50.4

specimens reared from the two hosts in Europe and New England since 1925 were compared with about 150 specimens resulting from our hybridization tests.

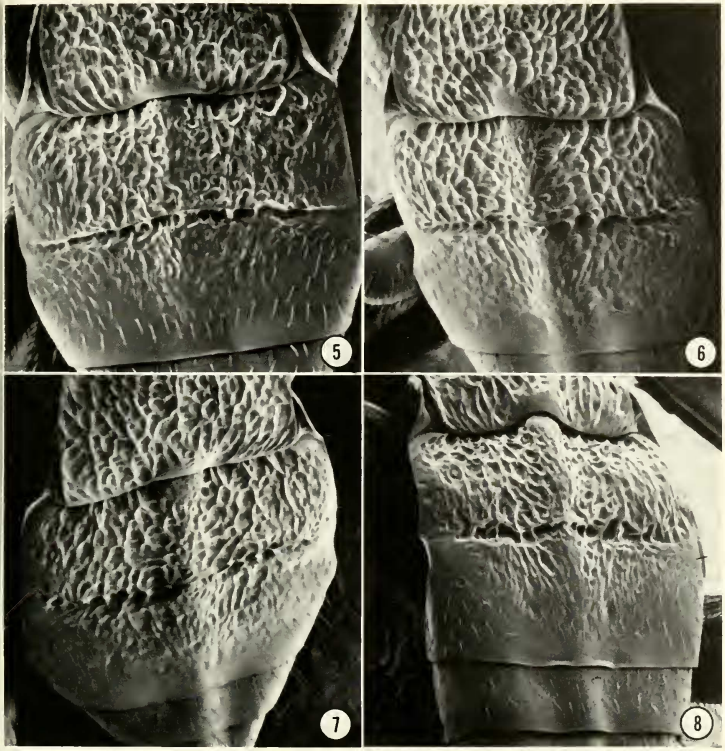
Results

Breeding Tests.—As shown in Table 1, *A. melanoscelus* and *A. solitarius* mated in the laboratory and produced fertile hybrid F_1 females (Table 1, crosses 3, 4). However, the number of crosses in which F_1 female progeny were not produced is significantly different[2] for the homogametic crosses (crosses 1, 2) compared to the heterogametic crosses (crosses 3, 4), which may indicate some type of genetic or behavioral isolation. Under these conditions, some all-male progenies probably result from a failure of the parent male to inseminate, rather than from hybrid sterility, and the high proportion of females in one of the backcrosses (cross 8) suggests that any genetic or behavioral isolation could be lost quickly.

The three Maine *A. solitarius* females crossed with CT *A. melanoscelus* males yielded at least one F_1 female in each of two crosses, suggesting reproductive compatibility although backcrosses were not done.

Morphological Examinations.—*Apanteles solitarius* and *A. melanoscelus* were both described by Ratzeburg in 1844. He distinguished the two species mainly by the color of the hind femur, that of *solitarius* being "at least light on basal half" and that of *melanoscelus* being "completely or nearly completely black." Obviously, a problem arises immediately as to what name to give a specimen with a partly black (or partly yellow) hind femur. Ratzeburg further distinguished the species by the degree of sculpturing on the second and third abdominal terga, that of *solitarius* being more extensive than *melanoscelus*. The characters used by Ratzeburg have since been shown to be among the most variable and difficult to interpret in the genus *Apanteles*.

[2] Chi-square test was used.



Figs. 5–8. Dorsal view of abdominal terga 2 and 3. 5, *Apanteles melanoscelus* female from Connecticut colony used in breeding experiments, hind femur pale brown edged with black. 6, *A. solitarius* female from British Columbia colony used in breeding experiments, hind femur pale brown edged with black. 7, F_1 female from SOL female × CT male cross. 8, F_1 female from CT female × SOL male cross.

The color of the hind femur of the specimens we examined ranges from entirely black to entirely yellow, each color variant having degrees of abdominal sculpturing, and there is no correlation between any of these variations and the host on which the specimen had been reared. The degree of difference in sculpturing between *melanoscelus* and *solitarius* is subtle or nonexistent (Figs. 1–8) and there is no correlation between the sculpturing and the hind femur coloration or the host species.

Discussion

In organisms that reproduce sexually, species must be separated by at least one reproductive isolating mechanism, including hybrid inviability or sterility, or by ethological or ecological isolation (Dobzhansky, 1972). The production of viable, fertile F_1 hybrid and backcross females by reciprocal crossing in the laboratory of the British Columbia colony and the CT *A. melanoscelus* colony demonstrates that these geographically isolated populations are not reproductively isolated. Since *A. solitarius*, the satin moth parasite, developed apparently normally in the gypsy moth under laboratory conditions, they apparently are not separated by host specificity. Differences in the production of female progeny (Table 1) suggest that there are some genetically based differences, but these do not appear to have achieved species status.

This study provides additional support for Nixon's (1974) synonymy of *A. melanoscelus* and *A. solitarius*, although future field studies could indicate that *A. melanoscelus* and *A. solitarius* are actually reproductively isolated where both hosts coexist because of their hosts' separate phenologies.

Acknowledgments

The following people provided specimens of *A. solitarius* from the satin moth: D. A. Ross, R. Wood, and L. Fiddick of the Pacific Forest Research Centre, Victoria, British Columbia; D. E. Leonard and T. Wagner of the Department of Entomology, University of Maine, Orono. R. Weseloh provided one of the *A. melanoscelus* colonies from Connecticut, and the exotic colonies from Europe were provided by L. Ertle, Beneficial Insects Research Laboratory, USDA, Newark, Delaware. Use of the scanning electron microscope for this project was supported in part by the Electron Microscope Central Facility, Center of Materials Research, University of Maryland, College Park, Maryland.

The work herein reported was funded in part by a USDA-sponsored program entitled the expanded Gypsy Moth Research and Applications Program.

Literature Cited

Brown, C. R. 1931. Observations on the satin moth and its natural enemies in central Europe. U.S. Dept. Agric. Circ. 176, 19 pp.

Burgess, A. F. and S. S. Crossman. 1927. The satin moth, a recently introduced pest. U.S. Dept. Agric. Bull. 1469, 22 pp.

Crossman, S. S. 1922. *Apanteles melanoscelus*, an imported parasite of the gypsy moth. U.S. Dept. Agric. Bull. 1028, 25 pp.

Dobzhansky, T. 1972. Species of *Drosophila*. New excitement in an old field. Science. 177(50):661–669.

Dowden, P. B. 1962. Parasites and predators of forest insects liberated in the United States through 1960. U.S. Dept. Agric., Agric. Handb. 226, 70 pp.

Howard, L. O. and W. F. Fiske. 1911. The importation into the United States of the parasites of the gypsy moth and the brown-tail moth. U.S. Dept. Agric. Bur. Entomol. Bull. 91. 344 pp.

Hoy, M. A. 1975a. Hybridization of strains of the gypsy moth parasitoid, *Apanteles melanoscelus*, and its influence upon diapause. Ann. Entomol. Soc. Am. 68:261–264.

———. 1975b. Forest and laboratory evaluations of hybridized *Apanteles melanoscelus* (Hymenoptera: Braconidae), a parasitoid of *Porthetria dispar* (Lepidoptera: Lymantriidae). Entomophaga 20:261–268.

Jones, T. H., R. T. Webber and P. B. Dowden. 1938. Effectiveness of imported insect enemies of the satin moth. U.S. Dep. Agric. Circ. 459. 24 pp.

McGugan, B. M. and H. C. Coppel. 1962. A review of the biological control attempts against insects and weeds in Canada. Part II. Biological control of forest insects, 1910–1958. CIBC Tech. Comm. No. 2:35–216.

Nixon, G. E. J. 1974. A revision of the northwestern European species of the *Glomeratus* group of *Apanteles* Foerster. Bull. Entomol. Res. 64:453–524.

Parker, D. L. 1935. *Apanteles "solitarius"* (Ratzeburg), an introduced braconid parasite of the satin moth. U.S. Dep. Agric. Tech. Bull. 477. 17 pp.

Ratzeburg, J. T. C. 1844. Die Ichneumonen der Forstinsecten. Nicolai, Berlin. Vol. 1. 224 pp.

Reeks, W. A. and C. C. Smith. 1956. The satin moth, *Stilpnotia salicis* (L.) in the Maritime Provinces and observations on its control by parasites and spraying. Can. Entomol. 88:565–579.